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ŠIFRANT PADAVINSKIH OBMOČIJ VODOTOKOV REPUBLIKE SLOVENIJE
WATERSHED CODING SYSTEM OF THE REPUBLIC OF SLOVENIA

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Pri planiranju in gospodarjenju z vodnim bogastvom potrebujemo preprost, informativen in razumljiv sistem šifriranja vodotokov in njihovih padavinskih območij. V nalogi so analizirani različni sistemi šifriranja evropskih držav in ZDA s poudarkom na razvoju sistema šifriranja za Slovenijo. Šifrant padavinskih območij Slovenije in njegova uporabnost sta predstavljena podrobneje.
Ključne besede: *hidrologija, padavinsko območje, šifrant*

Proper water resources planning and management requires a simple, yet descriptive and comprehensive coding system for rivers and their watersheds. Different coding systems in Europe and the USA are discussed in this paper, with an emphasis on a coding system developed for Slovenia. The coding system for Slovenia and its applicability are represented in greater detail.
Key words: *hydrology, watershed, coding system*

1. UVOD

Hidrološki modeli in analize, urejanje podatkov o okolju, izdelava vodnogospodarskih načrtov in programov ter izdelava sodobnih informacijskih sistemov za potrebe varstva okolja, zahtevajo enotno šifriranje padavinskih območij od celotnega povodja do najmanjšega povirja. Šifriranje padavinskih območij za omenjene potrebe ima v posameznih evropskih državah že večdesetletni in pester razvoj. Posamezni sistemi šifriranja se glede na izročilo in naravne pogoje v posameznih državah razlikuje.

Uporaba sodobne programske opreme za upravljanje s prostorsko določenimi bazami podatkov zahteva po eni strani šifriranje, ki je prilagojeno računalniški obdelavi podatkov, po drugi strani pa ponuja nove možnosti pri urejanju podatkov in izdelavi modelov. Kako pomemben je šifrant priča tudi dejstvo, da je tudi Evropska agencija za okolje za potrebe zbiranja in obdelave prostorsko določenih podatkov naročila izdelavo enotnega šifranta porečij Evropske skupnosti.

1. INTRODUCTION

Hydrological modelling and analysis, environmental database management and water management plans and programmes, as well as contemporary information systems for environmental protection, require a uniform watershed coding system from the level of the whole watershed to the level of the smallest headwaters. Watershed coding systems in European countries was developed several decades ago. Systems differ from country to country in view of natural conditions and tradition.

The application of contemporary software and hardware for managing spatially oriented data requires a computer adapted coding system and also offers new alternatives in data management and model making. The order of a uniform watershed coding system of the European Union for assembling and managing spatially oriented data by the European Environment Agency speaks of its importance.

Šifrant je med drugim tudi podlaga za izdelavo hidroloških modelov, ki so osnova za napovedovanje poplav, določanje poplavne ogroženosti in ukrepov varstva pred poplavami, račun vodne bilance itd.

Šifrant padavinskih območij omogoča tudi šifriranje strug posameznih vodotokov in njihovih odsekov ter klasifikacijo vodotokov glede na velikost povodij.

V Sloveniji sta bila v preteklosti izdelana dva sistema šifriranja vodotokov. Nobeden od njiju pa ni bil prilagojen računalniški obdelavi. Poleg tega sta bila oba sistema zaprta, saj nista omogočala nadaljnjega vključevanja manjših vodotokov. Nov sistem šifriranja je zelo podoben bavarskemu. Ta pa je v osnovi podoben tistemu, ki ga je Hidrološki inštitut (Institute of Hydrology) iz Wallingforda (Velika Britanija) predlagal Evropski agenciji za okolje. Slovenski šifrant se je uspešno vključil tudi v šifrant porečja Donave, ki je bil narejen za potrebe regionalnega programa IHP UNESCO.

Besides that, a coding system is the base for hydrological modelling. Hydrologic modelling is used for flood forecasting, flood risk analysis and precautions against floods, water budget assesments, etc.

A watershed coding system also enables the riverbed coding of individual streams and their segments and the classification of streams depending on their watershed size.

There have been two coding systems created in Slovenia in the past. Neither of them was adapted to computer processing. Both systems were closed. They didn’t enable the subsequent incorporation of smaller watersheds. The new system is very like Bavarian one, which is similar to the system that the Institute of Hydrology, Wallingford, UK proposed to the European Environment Agency. The Slovenian coding system fitted well into the Danube watershed coding system that was made for the purposes of the regional programme of IHP UNESCO.

2. IZDELAVA HIDROGRAFSKEGA KATASTRA REPUBLIKE SLOVENIJE

Podlaga za izdelavo šifranta padavinskih območij je kataster. Zadnje uradno izdelane karte za potrebe katastra so iz leta 1917 in še te le za porečje Save (Braumüller, 1917). V praksi so se meje podpovodij izdelovale po potrebi za posamezne študijske analize in izračune. Zato smo leta 1994, z uporabo arhivov Hidrometeorološkega zavoda Slovenije in Inštituta za kras SAZU, digitalizirali hidrografsko mrežo in razvodnice s temeljnih topografskih kart 1:25000 (Brilly & Garantini, 1994). Poseben problem so predstavljale razvodnice na kraškem območju, kjer so raziskave v zadnjih letih podale vrsto novih spoznanj o poteku razvodnic. Po končani digitalizaciji so bili podatki urejeni, organizirani, usklajeni in analizirani glede na točnost. Narejena je bila topološka in sistematična analiza, s pomočjo katere so bile odpravljene napake. Za potrebe šifranta so bile dodatno določene tudi nove razvodnice. Podatki so bili na koncu generalizirani in arhivirani po območjih posameznih kart (slika 1).

2. MAKING A HYDROGRAPHIC CADASTRE OF THE REPUBLIC OF SLOVENIA

The cadastre is a foundation for developing a watershed coding system. The last official maps for cadastre needs were made in 1917, but were for the Sava watershed only. In practice, boundaries of watersheds have been determined for individual study analyses and calculations only. In 1994, it was therefore decided to digitise hydrographic network and watershed boundaries from topographic maps 1:25000 (Brilly & Garantini, 1994) with the use of the Hydrometeorological Institute of the Republic of Slovenia and The Scientific Research Centre of the SASA archives. A special problem were the Karst watershed boundaries, where recent research provided new knowledge about flow directions. Afterwards, the digitised data were arranged, organised, adjusted and analysed for precision. Topology and systematic analyses were made in order to eliminate errors. New watershed boundaries were defined, additionally, for coding system needs. Finally, the data were generalised and archived within the original map structure (Figure 1).

Slika 1. Primer digitalizirane vsebine karte TK25 Sevnica z oznako 1443.
Figure 1. An example of the contents of the digitised map TK25 Sevnica, number 1443.

3. SISTEMI ŠIFRIRANJA PADAVINSKIH OBMOČIJ V RAZLIČNIH EVROPSKIH DRŽAVAH IN ZDA

Določanje šifer posameznim padavinskim območjem ima v Evropi že dolgo tradicijo. Pri tem so se glede na naravne pogoje, zgodovinski razvoj in izročilo razvili različni sistemi šifriranja, od skandinavskih sistemov, ki so usmerjeni bolj v opredelitev dotokov v akvatorij izredno razčlenjene obale, do bavarskih in čeških, kjer se voda zbira in odteka v večje vodotoke in ni neposrednega odtoka v morje.

Za vse prikazane primere velja hierarhični pristop in drevesna struktura. Tako so temeljne (začetne) šifre povsod vezane na glavni odvodnik oziroma vodotoke, ki se izlivajo v morje ali v druge vodotoke zunaj meja države. Sledi porazdelitev na podpovodja glede na velikost njihove prispevne površine ali vrstni red vtoka vodotokov v odvodnik.

3. WATERSHED CODING SYSTEMS IN EUROPEAN COUNTRIES AND THE USA

Watershed coding has a long tradition in Europe. According to natural conditions, historical development, and tradition, different coding systems that range from Scandinavian systems that are coastally oriented, to Bavarian and Czech systems, where the water flows in larger streams and where there is no direct draining into the sea, have been developed.

In all the cases there is a hierarchical principle and a tree structure. So the base (starting) codes always belong to the major river or the river that flows into the sea or into a transboundary river. Then watersheds are divided into several levels which relate to the surface area and inflow order.

3.1 NORVEŠKA

Na Norveškem so sistem šifriranja padavinskih območij izdelali leta 1989 (NVE, 1989) in ga poimenovali NORWIS (The Norwegian Water Information System). Temelj pri oblikovanju šifer je razdelitev Norveške na 262 enot, določenih na podlagi kart v merilu 1:50 000. Površina posameznih padavinskih območij je od 300 do 40000 m^2. Na najnižji ravni so dobili okrog 15000 podpovodij, vseh skupaj pa približno 26000. Šifre so oblikovane hierarhično. Vsaka naslednja raven je natančnejša od prejšnje (slika 2). Porazdelitev na manjše enote je precej zapletena, ker je sestavljena iz črk in številk, tako da šifra dobi obliko (npr.: 000.XXX.).

Norveški sistem šifriranja je prilagojen njihovim naravnim pogojem. Tako kot ostali skandinavski sistemi je usmerjen bolj v opredelitev dotokov v akvatorij izredno razčlenjene obale, zato ni uporaben za slovenske razmere. Poleg tega je sistem precej zapleten in manj uporaben za računalniško obdelavo podatkov.

3.2 DANSKA

Danska praksa je podobno kot norveška usmerjena v porazdelitev predvsem plitvega in razvejanega morskega akvatorija. Šifra je sestavljena iz številk in črk. Šifra ima obliko 0000-X-00-0000-0000-00-00-00-00-0/000000 (Danmarks Miljøundersøgelser Ferskvands-økologi, 1990).

Prva štiri mesta so rezervirana za šifriranje obalnega morja na štirih ravneh. Peto mesto zavzema črka, ki se nanaša na hidrološke lastnosti povodja oziroma izliva povodja. Tako pomeni črka V enotni gravitacijski vtok v morje, D delto, P črpalno postajo ipd. Tretji del šifre je predviden za šifriranje površinskih vodotokov. Pri tem je predvidena porazdelitev do osmega reda. Zadnji del šifre je predviden za dolžino med iztokom šifriranega vodotoka in izlivom vodotoka višjega reda.

Danski sistem šifriranja je podobno kot norveški prilagojen njihovim naravnim pogojem, tj. razvejanemu morskemu akvatoriju. V šifro so vključene tako črke kot tudi razdalje med vtoki in iztoki, zato je šifrant precej informativen, ni pa zgoščen in prijazen do uporabnika. Zaradi izpuščanja večjega števila cifer in prej omenjenih lastnosti šifranta, je ta manj uporaben za računalniško obdelavo podatkov.

3.1 NORWAY

The Norwegian watershed coding system was developed in 1989 (NVE, 1989), and was named NORWIS (The Norwegian Water Information System). The 262 major watersheds form the highest level in the classification. The coding is based on a 1:50000 scale. The area of individual watersheds is between 300 and 40000 m^2. There are approximately 15000 units at the lowest level and approximately 26000 units at all levels. The connection between the codes is hierarchical. Each higher level is more precise than the previous (Figure 2). Classification on the smaller units is quite complicated because of the combination of numbers and characters, such as 000.XXX.

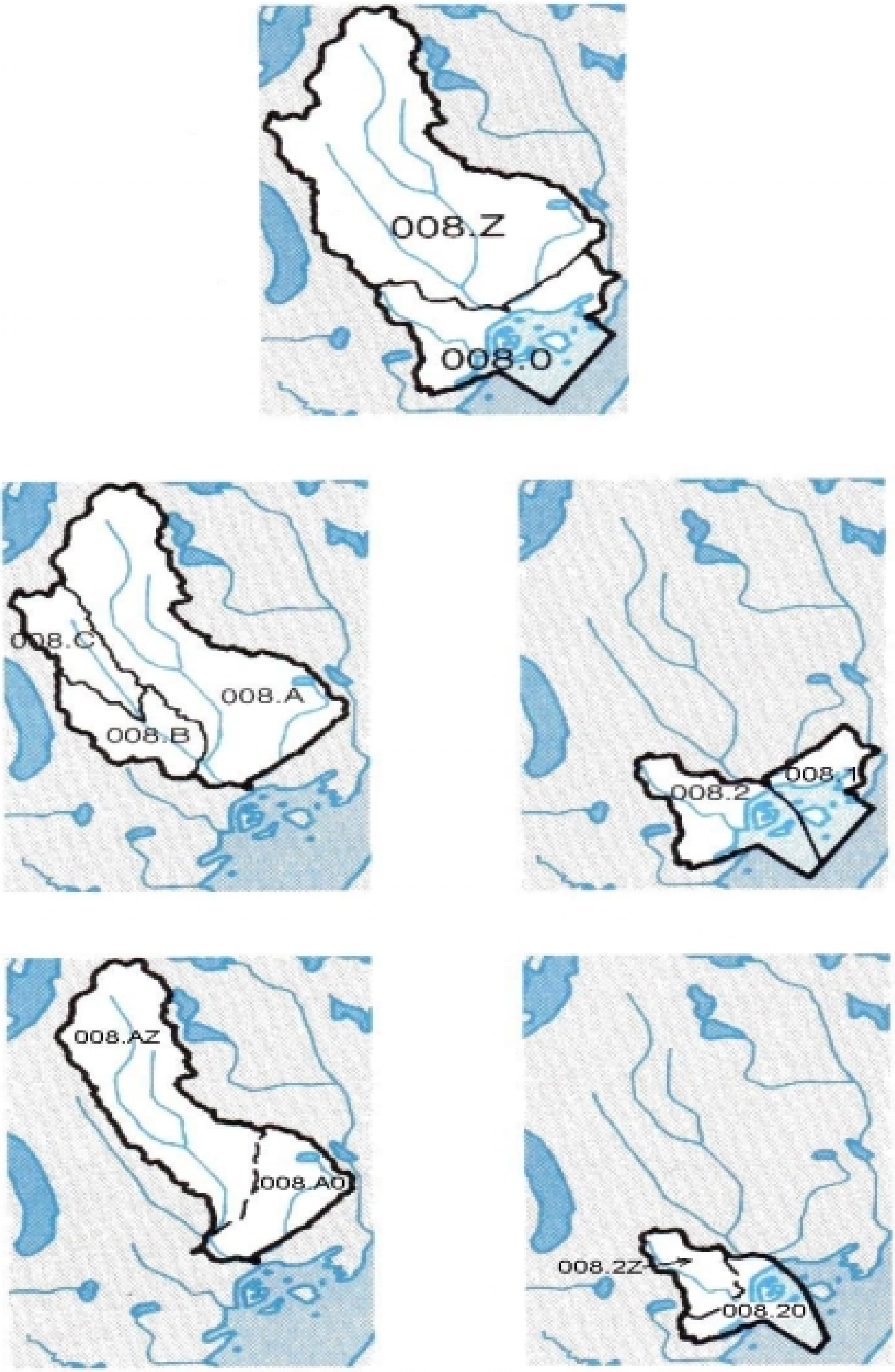
The Norwegian coding system is adapted to their natural conditions. It is coastally oriented like other Scandinavian systems, and for this reason, is not applicable to Slovenian circumstances. The system is complicated, as well, and therefore less applicable for computer data management.

3.2 DENMARK

The Danish practice is like the Norwegian - very site specific – and, therefore, coastally oriented. The code is a combination of numbers and characters. The code structure is 0000-X-00-0000-0000-00-00-00-00-0/000000 (Danmarks Miljøundersøgelser Ferskvands-økologi, 1990).

The first four digits are a marine reference code with four levels. The fifth digit is a character and is related to the hydrological characteristics of the stream and watershed. For example: V means a stream with a single outlet to the sea, D means a delta, P is a channel with a pumping station, etc. The third part of the code structure has twenty digits for the numbering of streams and watersheds up to the eighth order. The last part of the code is the distance between the outlet of the coded stream and the outlet of the stream on the higher level.

The Danish classification is, like the Norwegian, coastally oriented. There are characters and distances included in the code; that's why the system is very informative but unfriendly and unconcentrated on the other hand. Because of the need for leaving out several digits, the system is less applicable for computer data management.



Slika 2. Praktični primer šifriranja padavinskih območij na Norveškem (NVE, 1989).
Figure 2. Practical example of watershed coding in Norway (NVE, 1989).

3.3 FRANCIJA

V francoskem sistemu so povodja razdeljena na pet ravni. Šifra je sestavljena iz ene črke in petih številk X-0-0-0-00. Sistem je bil postavljen na državni ravni leta 1966. Celotna Francija je razdeljena na šest povodij, označenih za območje Rhone in Sredozemlja s črkami: U - Saone, V - Rhone, W - Isere, X - Durance in ostala majhna povodja, ki se zlivajo neposredno v morje. Večja povodja se nato delijo na manjša v treh ravneh (sektorje, podsektorje in cone), največ na deset delov. Zadnji dve številki sta uporabljeni za šifrirano številčno identifikacijo.

3.4 ČEŠKA

Češki model šifriranja je bil zasnovan leta 1979 na podlagi kart 1:50000 (Česky hydrometeorologicky ustav, 1993). Sistem je pogojen z geografskimi pogoji Češke, ki nima morske obale in večjih zakraselih prepustnih površin. Šifra je sestavljena samo iz številk in ima obliko 0-00-00-000. Povodja so porazdeljena v štiri razrede. Prvi razred deli Češko na tri (skupaj s Slovaško na štiri) glavna porečja: 1 - Laba, 2 - Odra, 3 - Visla in 4 - Donava.

Češki sistem šifriranja je glede na njihove geografske pogoje za nas bolj sprejemljiv. V šifri ne uporabljajo črk, njihova šifra pa je sestavljena iz dvo- in tromestnih števil, kar prav tako otežuje računalniško obdelavo podatkov.

3.5 NEMČIJA IN BAVARSKA

Šifriranje bavarskih vodotokov je bilo izdelano leta 1978 na podlagi enotnih nemških smernic (Bayerisches Landesamt für Wasserwirtschaft, 1978). Sistem določanja šifer je oblikovan drevesno in vsebuje sedem ravni (slika 3). Prva številka se nanaša na glavna povodja Nemčije: 1 - Donava, 2 - Ren, 3 - Ems, 4 - Weser, 5 - Elba, 6 - Odra in 9 - umetno ustvarjena vodna območja (LAWA, 1993).

3.3 FRANCE

In France, streams and watersheds are divided into five levels. The code consists of one character and five numbers, such as X-0-0-0-00. Classification was made on a technical act passed in 1966. The country is divided into six watersheds in the first level signed by a character. The Rhone – Mediterranean region is subdivided into: U – Saone, V – Rhone, W - Isere, X – Durance and other small watersheds with outflow into the Mediterranean Sea. The major watersheds are divided into the smaller on three levels (sector, subsector and zone). Each level contains up to ten subwatersheds. The last two digits are used for identification.

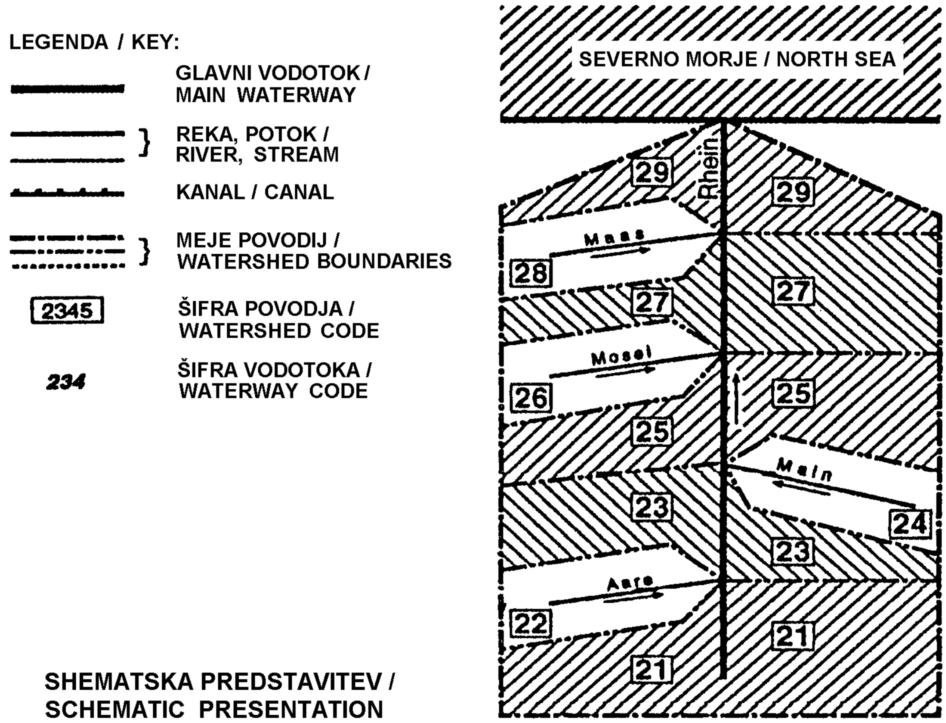
3.4 CZECH REPUBLIC

The Czech coding system was established in 1979, and is based on 1:50000 scale maps (Česky hydrometeorologicky ustav, 1993). The system is dependant on the geographical conditions of the country, which has no coast and no larger karst regions. The classification has four levels and is presented by an eight digit number such us 0-00-00-000. The first level divides Czech into three (including Slovakia, four) major watersheds: 1 - Laba, 2 - Odra, 3 – Visla, and 4 – Danube.

The Czech system is, in view of their geographical conditions, more acceptable for us. They don’t use characters, but on the other hand, they use two or three-figure numbers, and that is less applicable for computer data management.

3.5 GERMANY AND BAVARIA

The watershed coding system of Bavarian streams was made in 1978 based on uniform German guidelines (Bayerisches Landesamt für Wasserwirtschaft, 1978). The system is hierarchical and has seven levels (Figure 3). Each code is a seven digit number. The first digit indicates one of the main German watersheds: 1 - Danube, 2 - Rein, 3 - Ems, 4 - Weser, 5 - Elba, 6 – Odra, and 7 – coastal watersheds (LAWA, 1993).



Slika 3. Shematska predstavitev šifriranja povodja Rena (LAWA, 1993).
Figure 3. Schematic presentation of the Rhine River coding system (LAWA, 1993).

Številči se od izvira dolvodno, tako da številka ena pomeni območje z izvirom vodotoka, nato pa se z lihimi številkami označijo območja ob glavnem toku, s sodimi pa stranski vodotoki od izvira dolvodno.

Bavarski sistem šifriranja je informativen, zgoščen, odprt in prijazen do uporabnika. Tudi geografski pogoji v Nemčiji so zelo podobni slovenskim.

The numbering starts upstream so that the source of the stream is assigned number one. Odd numbers are used for the main stream and even numbers for tributaries in the downstream direction.

The Bavarian coding system is informative, concentrated, open and friendly to users. German geographical conditions are also very like those of Slovenia.

3.6 AVSTRIJA

Avstrijski sistem je zasnovan na razdelitvi povodij na devet ravni. Šifra je enaindvajset-mestno število (Behr, 1989). Struktura je drevesna in hierarhična, številčenje poteka od izvira dolvodno. Sistem je osredotočen predvsem na rečno mrežo in ne na velikost prispevnih površin.

Pomembno je, da se območja neposredno ob vodotoku kasneje ne delijo več. Šifre niso vezane na velikost povodja in se celotne (enaindvajsetmestne šifre) pojavijo le redko. Razvodnice so določene na kartah v merilu 1:50000. Določanje površin posameznih območij in imen vodotokov še ni končano.

3.6 AUSTRIA

The Austrian system has nine levels, and it's presented by a twenty one digit number (Behr, 1989). The system has a tree structure and is hierarchical. Numbering starts upstream. First of all, the system is concentrated on the stream network and not on watershed size.

It is important that the main stream watersheds are not divided further. Codes are not related to the watershed size and they rarely appear in their entirely (as twenty one digit numbers). Watershed boundaries have been defined on 1:50000 scale maps. The watershed area and stream name definitions haven't been completed yet.

3.7 EVROPSKA SKUPNOST

Hidrološki inštitut (Institut of Hydrology) iz Wallingforda v Veliki Britaniji je v sodelovanju z danskim raziskovalnim inštitutom (National Environmental Research Institute), po naročilu Evropske agencije za okolje, pripravil študijo o obstoječih digitalnih hidrografskih katastrih v državah EU ter o možnostih priprave enotnega šifranta za Evropsko skupnost (Morris, 1994). V raziskavo je bilo zajetih 12 držav Evropske skupnosti: Belgija, Danska, Francija, ZR Nemčija, Grčija, Irska, Italija, Luksemburg, Nizozemska, Portugalska, Španija in Velika Britanija, pet držav EFTA: Avstrija, Finska, Norveška, Švedska in Švica, ter deli držav iz katerih se vode stekajo na območje EU: Bolgarija, nekdanja Češkoslovaška, Poljska in nekdanja Jugoslavija. Celotna površina obravnavanega območja je bila približno 3,85 milijonov km^2. Izločili so 15 glavnih vodotokov s prispevno površino, večjo kot 50 000 km^2 (slika 4). Največje je padavinsko območje Donave, katerega le majhen del leži na obravnavanem območju. Zanimivo je tudi padavinsko območje Rena, ki se razteza kar čez osem držav.

Zaključki študije so, da naj bo celotna šifra sestavljena iz treh delov: glavne delitve, šifre ustja vodotoka in šifre vodotoka.

Za glavno delitev so predlagali šifriranje morij in obal. Primer: NB40 (North Sea, British coastline, sektor 40). Drugi del šifre bi povedal velikost vodotoka. Primeri: RH za velike vodotoke, BI za srednje in 'be' za majhne vodotoke. Tretji del je šifra vodotoka. Predlagani sistem je nemški.

Celotna šifra bi bila na primer (Morris, 1994):

NC10_RH_4792R74 - za pritok Rena;

NB37_be_R5 - za pritok reke Bean, Essex v Veliki Britaniji.

3.7 EUROPEAN UNION

The Institute of Hydrology, Wallingford, UK, together with the National Environmental Research Institute of Denmark, conducted the study about existing digital hydrographic cadastres in the EU countries and the possibilities of preparing a uniform coding system for the EU (Morris, 1994). The study covers twelve countries of EU: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and the UK; five EFTA countries: Austria, Finland, Norway, Sweden and Switzerland; and, because they drain into EU territory, parts of the following countries: Bulgaria, the former Czechoslovakia, Poland, and former Yugoslavia. The total area covered by the study was approximately 3,85 million square kilometres. They separate 15 major rivers with a catchment area greater than 50 000 km^2 (Figure 4). The largest of these, the Danube, discharges into the Black Sea, and only a small part of its catchment lies in the study region. One other point worthly of special note is the international nature of the Rhine, whose catchment spreads over eight countries.

The study has suggested a system based on major division, mouth code and river system code.

A marine code was suggested for major divisions. Example: NB40 (North Sea, British coastline, sector 40). The second part of the code would describe the river size. Examples are: RH, BI, 'be' for large, medium and small rivers. The third part of the code would be the river code. A German method was suggested.

The system would give codes such as (Morris, 1994):

NC10_RH_4792R74 – for a Rhine tributary;

NB37_be_R5 - for a reach of the River Bean, in Essex, England.

Slika 4. Glavnih 15 vodotokov na območju EU (povzeto po Morris, 1994).
Figure 4. The fifteen major rivers in the EU region (after Morris, 1994).

3.8 ZDA

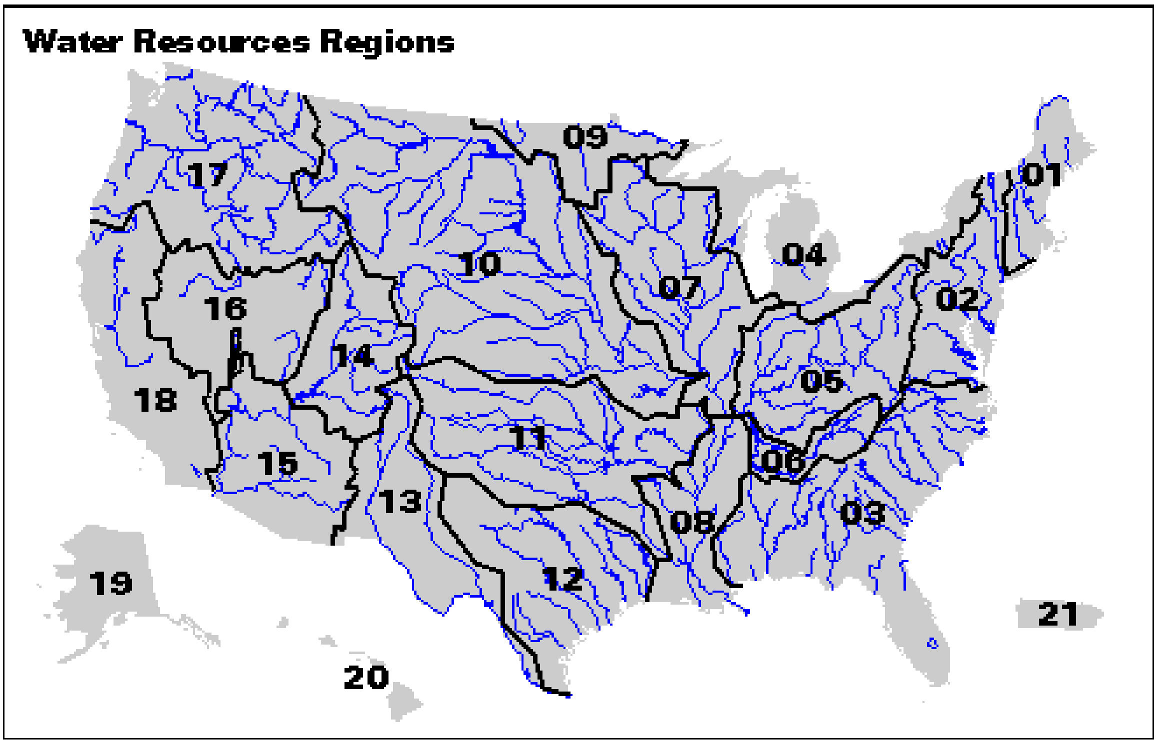
Sistem šifriranja v ZDA je izdelala ameriška vladna geološka služba (USGS – U. S. Geological Survey). Šifrant ima štiri ravni. Vsako padavinsko območje (hydrologic unit – HU) ima svojo dvo- do osemmestno šifro (hydrologic unit code – HUC) (http://water.usgs.gov/GIS/huc.html). Na prvi ravni so ZDA razdeljene na 21 večjih geografskih območij, regij (slika 5). Šifra je dvomestna. Sistem ni hierarhičen. Na četrti ravni so dobili 2150 padavinskih območij. Za vsako zvezno državo imajo izdelano karto padavinskih območij s šifrantom v merilu 1:500 000, ki jo je mogoče naročiti tudi preko spleta.

3.8 USA

The watershed coding system in the USA was done by the U.S. Geological Survey – USGS. The system has four levels. Every watershed (hydrologic unit – HU) has it's own two- to eight-figure number (hydrologic unit code – HUC) (http://water.usgs.gov/GIS/huc.html). The first level divides the USA into 21 major geographical regions (Figure 5). The code is a two-figure number. The system is not hierarchical. They get 2150 watersheds on the fourth level. Every federal state has its own map of watersheds based on a 1:500 000 scale. You can order maps by internet.

Preko spleta poskušajo padavinska območja približati tudi prebivalcem. Pod naslovom "Spoznajte svoje padavinsko območje" lahko na spletu najdejo različne podatke, vezane na posamezno območje (http://www.epa.gov/ surf3/locate/). Spletne strani je postavila ameriška agencija za zaščito okolja (EPA). Uporabnik lahko svoje območje poišče zelo preprosto po imenu kraja, šole, reke itd. ali pa s pomočjo interaktivne karte. Podatki, ki jih lahko najde, pa so poleg splošnih o velikosti območja, dolžini vodotokov, tudi geografski, podatki o monitoringih, kakovosti vode, geologiji, podatki o projektih, o lokalnih aktivnostih, organizacijah itd.

They also try to introduce watersheds online. On the web page "Surf Your Watershed", one can find various data about one's individual region (http://www.epa.gov/surf3/locate/). The internet pages were published by the Environmental Protection Agency (EPA). Everyone can find his own region simply by searching for the name of the town, school, or river, or by using an interactive map. One can find general data about watershed size, length of the streams and also geographical, monitoring, water quality, geological data, projects, local activities, organisations etc.



Slika 5. Razdelitev ZDA na prvi ravni (http://water.usgs.gov/GIS/huc.html).
Figure 5. The first level coding of the USA (http://water.usgs.gov/GIS/huc.html).

4. IZDELAVA ŠIFRANTA PADAVINSKIH OBMOČIJ REPUBLIKE SLOVENIJE

4.1 IZHODIŠČA ZA IZDELAVO ŠIFRANTA

Izdelava sistema šifriranja, uporabnega za različne potrebe urejanja podatkov, vključno s hidrološkim modeliranjem, je zelo kompleksna naloga. Šifrant mora biti informativen, zgoščen, odprt in prijazen do uporabnika (Brilly & Vidmar, 1994, Vidmar & Brilly, 1992).

Da je šifrant *informativen*, pomeni, da nam mora šifra, ki je identifikator določenega padavinskega območja, dati tudi informacijo o razmerjih med povodji in podpovodji, o velikosti prispevne površine, ločiti gorvodne od dolvodnih območij. Šifra kot identifikator torej ne sme biti samo skupina naključno izbranih številk in črk.

Zgoščenost pomeni, da je šifra čim krajša in da jo lahko uporabljamo na različnih ravneh v različni velikosti. Dolga vrsta številk in črk ni praktična, če se posamezni deli šifre le redko uporabljajo. Dolge šifre so neprijazne do uporabnika in zahtevnejše za računalniško programiranje.

Odprt sistem se mora preprosto prilagajati potrebam mednarodnega informacijskega sistema na višjih ravneh in omogočiti vključevanje tudi najmanjših padavinskih območij na nižjih ravneh.

Da bi bil sistem tudi *prijazen*, mora biti šifra razumljiva uporabnikom in perprosta za uporabo, predvsem za računalniško obdelavo podatkov. Črke v šifri so za uporabnike bolj razumljive, tudi lažje si jih zapomnijo, a so bolj neprijazne za računalniško obdelavo.

4. DEVELOPMENT OF THE WATERSHED CODING SYSTEM OF THE REPUBLIC OF SLOVENIA

4.1 BASIS FOR DEVELOPMENT OF THE CODING SYSTEM

The development of a coding system applicable to various needs of data management, including hydrological modelling, is a complex task. The system must be informative, concentrated, open and friendly (Brilly & Vidmar, 1994, Vidmar & Brilly, 1992).

Informative means that a code that is an identifier of a specific watershed should give additional information about the relationship between different watersheds and subwatersheds, and the description of the size of the watershed, and should separate upstream from downstream watersheds. A code as identifier shouldn’t be just a group of randomly selected numbers and characters.

Concentrated means that a code should be as short as possible and applicable to different levels in different sizes. A large string of numbers and characters is not practical if some parts of the string are rarely used. Large codes are also unfriendly and complicated for computer programming.

An open system should be easily adaptable to any international information system on higher levels, and should enable the incorporation of smaller watersheds on lower levels, as well.

Friendly means that a code should be understandable for the users and easy to handle, especially for computation purposes. The characters in the code are easier to understand and remember for the users, but unfriendly for computer handling.

4.2 SLOVENIJA (DO LETA 1995)

4.2.1 METODOLOGIJA, IZDELANA NA VODNOGOSPODARSKEM INŠTITUTU

Metodologija (Pintar in ostali, 1987) je temeljila na že pred letom 1969 izdelani metodologiji nekdanjih republik Jugoslavije. Metodologija je temeljila na decimalni klasifikaciji vodotokov. Glavni odvodnik porečja je bil brez reda, njegovi neposredni pritoki so bili vodotoki prvega reda itd. Glavni odvodniki so bili: obalno morje, Drava, Mura, Sava in Soča. Vodotoki so se številčili od izvira navzdol.

Ker šifrant ni narejen v digitalni obliki, je bil zaradi prikaza v nalogi podigitaliziran primer (slika 6) s podlog v merilu 1:10000.

Šifrant je, poleg zaporedne številke pritoka, vseboval tudi kilometražo, površino padavinskega območja, dolžino odvodnika, nagib in povprečno nadmorsko višino. Namenjen je bil predvsem izdelavi katastra vodnogospodarskih objektov.

Sistem je zaprt, saj ne omogoča naknadnega vključevanja manjših vodotokov oziroma zahteva ponovno številčenje.

Ker so padavinska območja, s katerih voda odteka neposredno v vodotok, neoštevilčena, je nemogoče sestaviti celoten sistem odtoka. Tak sistem šifriranja ni primeren za hidrološko modeliranje.

4.2. SLOVENIA (TO 1995)

4.2.1. WATER MANAGEMENT INSTITUTE METHODOLOGY

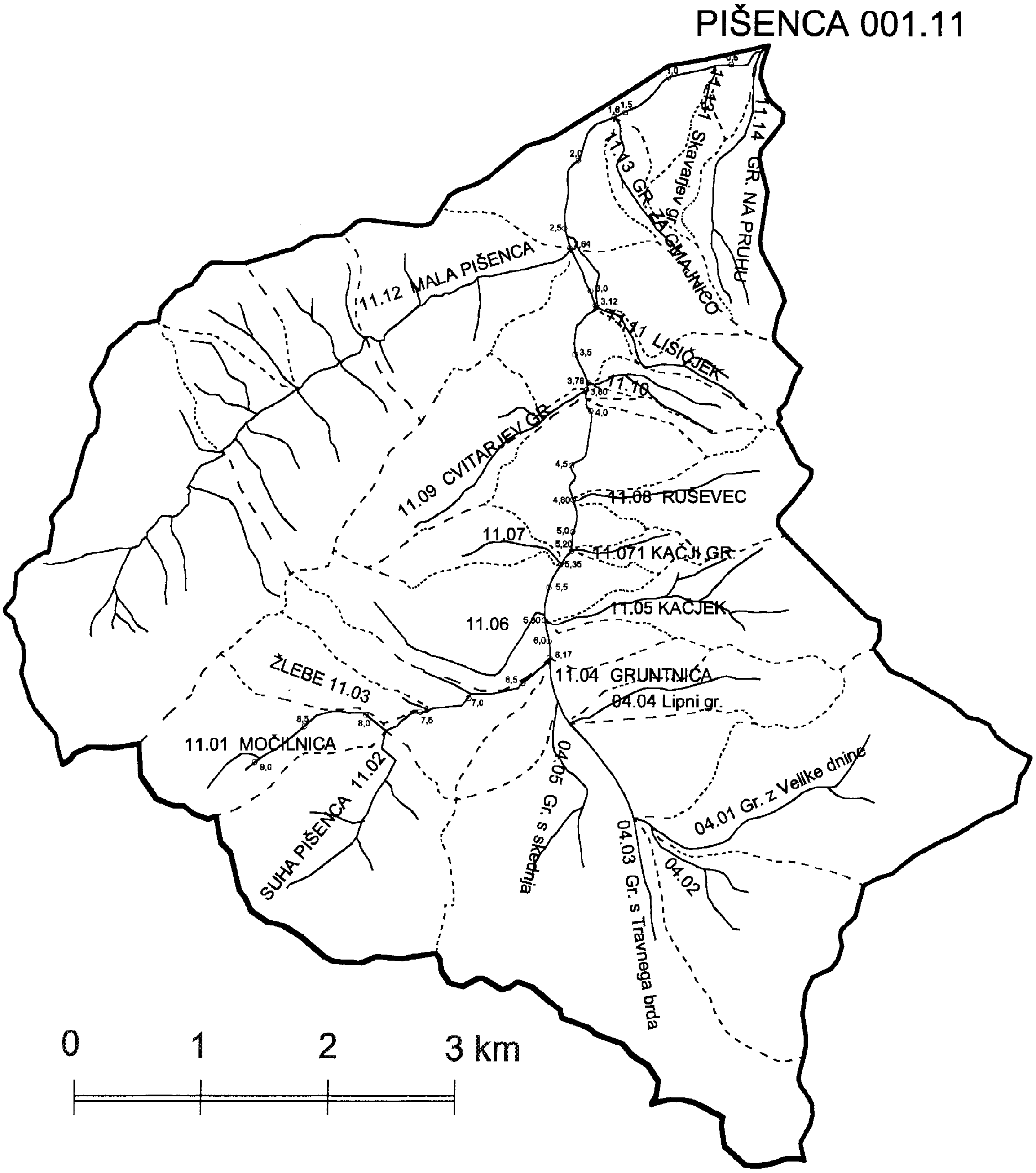
The methodology (Pintar et al., 1987) was based on the methodology of the former Republics of Yugoslavia created before 1969. It was based on a decimal river classification. The main stream of the watershed was level “0", its direct tributaries were first level, etc. the main streams were: the coastal sea, and the Drava, Mura, Sava and Soča rivers. Numbering started at the source of the stream and then continued in the downstream direction.

Because the system wasn’t made in digital form, a part of it (Figure 6) was digitised from 1:10000 scale maps for the purpose of presentation in this paper.

The coding system contained the sequence number of a tributary, measured in kilometres, the watershed area, the length of the stream, the slope and the average height above sea level. It was designed for a cadastre of hydraulic structures, above all.

The system is closed. It doesn’t enable the additionally incorporation of smaller streams, and requires new numbering, respectively.

Because the main stream watersheds have no numbers, it is impossible to compose the entire outflow system. Such a system is not appropriate for hydrological modelling.



Slika 6. Primer šifranta Pišence po metodologiji VGI.
Figure 6. Example of Pišenca coding by VGI methodology.

4.2.3 METODOLOGIJA, IZDELANA NA HIDROMETEOROLOŠKEM ZAVODU SLOVENIJE LETA 1986

Leta 1986 je bil kataster in šifrant vodotokov Slovenije izdelan tudi na HMZ (Stele, 1986). Temelj tega katastra je bila rečna mreža, podana na kartah v merilu 1:25000. Vodotoki so bili številčeni hierarhično glede na vrstni red vtoka od izliva gorvodno.

Struktura šifre je bila sestavljena z več ravni. Pri tem je bil glavni odvodnik porečja brez reda, njegovi neposredni pritoki so bili vodotoki prvega reda itd. Sistem je predvideval vključevanje vodotokov do sedmega reda, pri čemer so bili v katastru leta 1988 obdelani vodotoki do petega reda. Za glavni vodotok je bilo v šifri predvideno eno mesto, za vodotoke prvega in drugega reda po tri mesta, za vodotoke tretjega, četrtega in petega reda pa po dve mesti. Šifra je bila trinajstmestno število z obliko: 0-000-000-00-00-00. Primer šifre Topliškega potoka 3-101-048-02-17-07 je na sliki 7.

Glavni odvodniki so bili: Jadransko morje, Mura, Drava, Sava, Soča in Kolpa.

Zaradi vključevanja velikega števila vodotokov z relativno majhnimi prispevnimi površinami že na prvi ravni, je ostalo veliko podatkov v katastru nedoločenih. Značilno je predvsem veliko število neimenovanih vodotokov. Celotna šifra je dokaj neprijazna in zaprta, saj ne omogoča vključevanja manjših vodotokov ali sprememb zaradi vodnogospodarskih posegov in zahteva vnovično številčenje. Površine, s katerih se voda steka neposredno v vodotok, so izključene iz številčenja oziroma je posamezne dele povodja težko povezati s celotnim sistemom. Zato je sistem za potrebe vodnogospodarskega informacijskega sistema in uporabo GIS neprimeren.

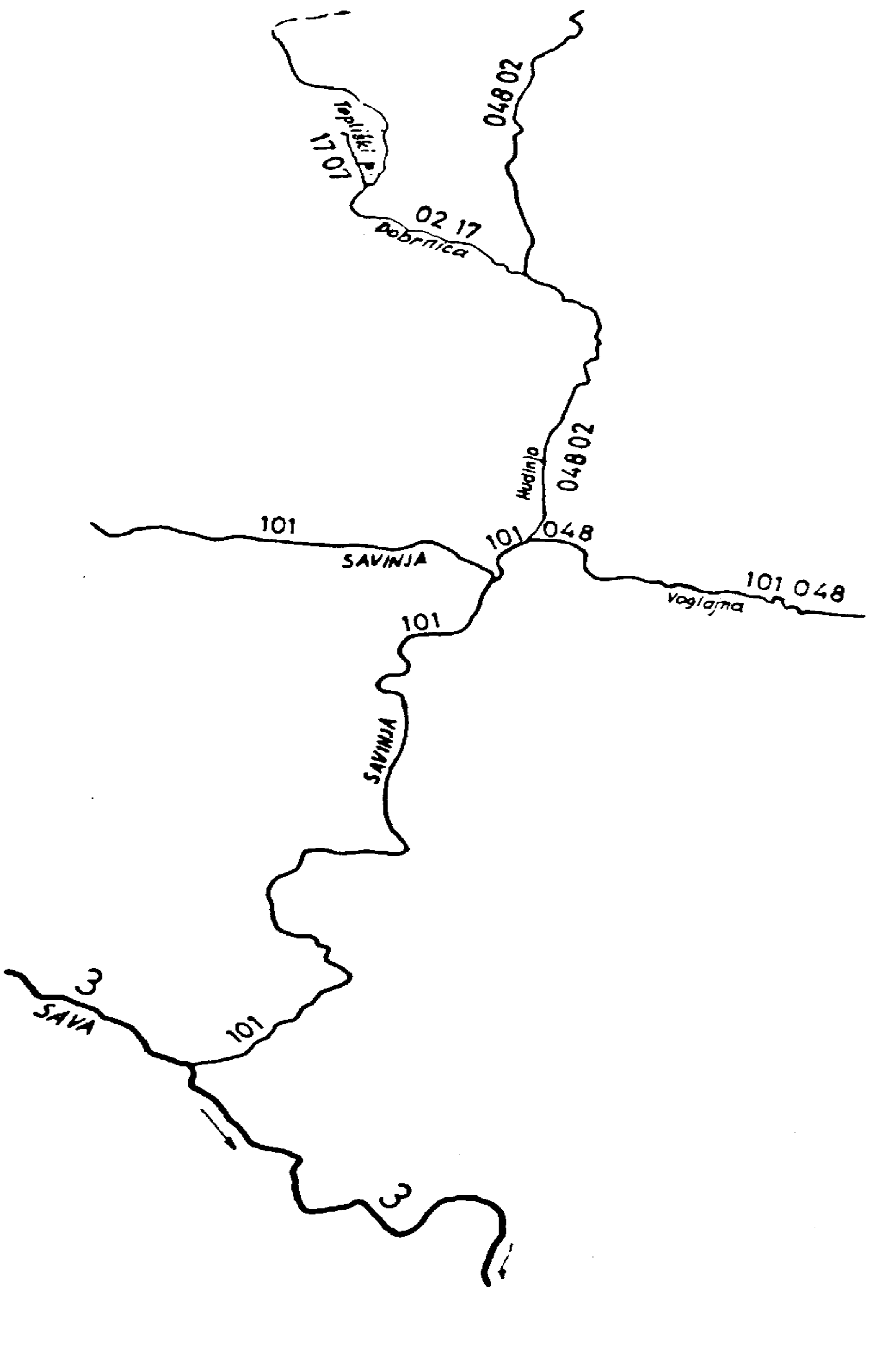
4.2.3 METHODOLOGY MADE BY THE HYDROMETEOROLOGICAL INSTITUTE OF SLOVENIA IN 1986

In 1986 the cadastre and coding system of the Slovenian rivers was created by the Hydrometeorological Institute of Slovenia also. The foundations of the cadastre was the stream network obtained from 1:25000 scale maps. Streams were numbered hierarchically starting from the outflow upstream.

The structure of the code had several levels. The main stream was level “0”, its direct tributaries were first level, etc. The system foresaw a coding to the seventh level, but in the cadastre from 1988 only streams to the fifth level were captured. The first digit in the code indicated main stream, then streams on the first and second level had three digits and streams on the third, fourth and fifth level, two digits. The code was a thirteen-figure number such as 0-000-000-00-00-00. An example of the Topliški potok code is: 3-101-048-02-17-07 (Figure 7).

The main streams were: the Adriatic sea, and the Mura, Drava, Sava, Soča and Kolpa rivers.

Because of the inclusion a large number of streams with relatively small contribution areas already on the first level, a lot of data in the cadastre remained undetermined. A large number of unnamed streams is significant. The code is rather unfriendly and closed. It doesn’t enable the additionally incorporation of smaller streams or changes of water management interventions, and requires new numbering, respectively. Main stream areas weren't included in the coding system so it was hard to connect individual areas with the entire system. For this reason the system isn't appropriate for water management information system and GIS application.



Slika 7 - Primer določanja šifer vodotokov v Sloveniji iz leta 1986 za Topliški potok (Stele, 1986).
Figure 7. Example of stream coding in Slovenia in 1986 for Topliški potok (Stele, 1986).

4.3 NOVA METODOLOGIJA ŠIFRIRANJA SLOVENSKIH PADAVINSKIH OBMOČIJ

Na podlagi analize različnih načinov šifriranja v različnih državah smo izdelali sodoben sistem za določanje šifer padavinskih območij v Sloveniji. Sistem je odprt in omogoča preproste povezave do globalne svetovne ravni navzgor, kakor tudi vključevanje najmanjših potokov. Šifre omogočajo tudi opredelitev približne velikosti povodja, položaja posameznih delov povodja, odnos med gorvodnimi in dolvodnimi povodji ipd.

Pri iskanju temeljnih načel in pravil za potrebe Slovenije smo upoštevali omenjena izhodišča. Kot rezultat smo dobili temeljni sistem, podoben bavarskemu. Številčenje se začne pri izviru, tako da povodje izvira dobi šifro 1. Povodja glavne struge se številčijo z lihimi števili, stranski dotoki pa s sodimi v dolvodni smeri. Enako velja pri morski obali: z lihimi števili označujemo del obale z razpršenim ali nedoločenim neposrednim odtokom v morje, s sodimi pa vodotoke, ki imajo vtok določen z ustjem ali delto. V temeljih podoben sistem je Hidrološki inštitut (Institute of Hydrology) iz Wallingforda v Veliki Britaniji predlagal tudi Evropski agenciji za okolje, ki si je izdelavo šifranta vodotokov držav Evropske skupnosti zadala za eno od prvih nalog. Pomen šifranta je torej izjemen. Pri tem pa moram opozoriti, da Slovenija s svojim šifrantom izstopa med vsemi državami Evropske skupnosti (Morris, 1994; preglednica 1). Iz preglednice je razvidno, da so le redke države, ki imajo podatke zbrane s takšno natančnostjo in vsebino kot Slovenija.

Sistem šifriranja padavinskih območij je hierarhičen z delitvijo na več ravni v odvisnosti od velikosti prispevne površine. Pri šifriranju se upoštevajo celotna povodja posameznih vodotokov, vključno z deli zunaj Slovenije. Delitev na posamezna podpovodja je omejena na največ devet delov celote, tako da za vsako raven potrebujemo samo eno mesto v šifri. Vsak vodotok oziroma povodje se mora v strukturi pojaviti s svojo enotno šifro.

4.3. NEW METODOLOGY OF WATERSHED CODING IN SLOVENIA

A contemporary coding system for Slovenian watersheds based on the analysis of different coding systems in different countries has been made. The system is open and enables a simple connection with the global world level, as well as the incorporation of the smallest streams. The codes enable the determination of the approximate size of a watershed, the position of individual watersheds, the relationship between upstream and downstream watersheds, etc.

By searching the elementary principles and rules for Slovenia we used the above mentioned basis. As a result a system similar to the Bavarian one was created. Numbering starts at the upstream end, so the source of the stream is assigned number One. Odd numbers are used for the main stream watersheds and even numbers for tributaries in the downstream direction. The same holds good for the coast. Even numbers get a part of the coast with dispersed or indefinite direct outflow into the sea, and odd numbers, streams with mouth or delta outflow. A basic similar system was suggested by the Institute of Hydrology, Wallingford, UK to the European Environmental Agency. The river coding system of the European Union was one of the first tasks of the Agency. The coding system is therefore significant. It must be mentioned that Slovenia, with its system, has surpassed many countries of the European Union (Morris, 1994; Table 1). As we can see in the table, there are few countries with such accurate data and content as Slovenia.

The watershed coding system of Slovenia is hierarchical, with divisions on several levels which are dependant on the size of the contribution area. Whole watersheds of individual rivers, including parts outside the country, were considered within the coding. The division on individual subwatersheds is limited to no more than nine parts, so only one digit in the identifier number of the watershed and corresponding stream for each level is needed. Each watershed or stream can appear in the structure with its own unique number.

Na prvi, najvišji ravni, smo Slovenijo razdelili na šest glavnih padavinskih območij (slika 8):

1. porečje Save;
2. porečje Kolpe;
3. porečje Drave;
4. porečje Mure;
5. porečje obale;
6. porečje Soče.

Velikost padavinskih območij prve ravni je od 1100 km^2 (padavinsko območje Kolpe) do 10675 km^2 (padavinsko območje Save).

On the first, i.e.: the highest level, we divided Slovenia into six major watersheds (Figure 8):

1. Sava watershed;
2. Kolpa watershed;
3. Drava watershed;
4. Mura watershed;
5. Coast watershed;
6. Soca watershed.

The size of the watersheds on the first level is from 1100 km^2 (Kolpa watershed) to 10675 km^2 (Sava watershed).

Preglednica 1. Pregled digitalizirane hidrografije evropskih držav (Morris, 1994).

DRŽAVA	MERILO	VIR	PROJEKCIJA	GIS	ŠIFRANT
Avstrija	1:50 000	uradne karte	Gauss-Krüger	-	ne
Danska	1:100 000	različni viri	UTM cona 32	ARC/INFO	da
Nemčija[1]	1:200 000	TUK 200	-	ARC/INFO	da
Nemčija[2]	1:300 000	hidrografske karte	Gauss-Krüger	ALC-GIAP	da
Velika Britanija	1:250 000	cestna karta	državna mreža	NTF	ne
S. Irska	1:250 000	počitniška karta	Transverse Mercator	ARC/INFO	da
Nizozemska	1:50 000	hidrografske karte	državna mreža	ARC/INFO	da
Norveška	1:50 000	M711	UTM ED 50	DXF	da
Poljska	1:200 000	hidrografske karte	Lat.-Long.	ARC/INFO	ne
Portugalska	1:500 000	uradne karte	Gauss	DGN	ne
Španija	1:200 000	provincialne karte	UTM	DXF, DGN	ne
Švedska	1:250 000	cestna karta	državna mreža	ARC/INFO	da
Švica	1:200 000	uradne karte	državna mreža	ARC/INFO	da
Slovenija	**1:25 000**	**uradne karte**	**Gauss-Krüger**	**AutoCAD**	**da**

[1] celotna Nemčija (1995); [2] pokrajina Nordrhein-Westfalen

Table 1. Review of digitized hydrography in Europe countries (Morris, 1994).

COUNTRY	SCALE	MAP SERIES	COORD. SYSTEM	GIS	CODING
Avstria	1:50 000	Official maps	Gauss-Krüger	-	no
Denmark	1:100 000	Different	UTM cona 32	ARC/INFO	yes
Germany[1]	1:200 000	TUK 200	-	ARC/INFO	yes
Germany[2]	1:300 000	Hydrographic maps	Gauss-Krüger	ALC-GIAP	yes
Great Britain	1:250 000	Routemaster	National grid	NTF	no
N. Ireland	1:250 000	Holiday map	Transverse Mercator	ARC/INFO	yes
Netherland	1:50 000	Hydrographic maps	National grid	ARC/INFO	yes
Norway	1:50 000	M711	UTM ED 50	DXF	yes
Poland	1:200 000	Hydrographic maps	Lat.-Long.	ARC/INFO	no
Portugal	1:500 000	Official maps	Gauss	DGN	no
Spain	1:200 000	provincial maps	UTM	DXF, DGN	no
Sweden	1:250 000	Road maps	National grid	ARC/INFO	yes
Switzerland	1:200 000	Official maps	National grid	ARC/INFO	yes
Slovenia	**1:25 000**	**Official maps**	**Gauss-Krüger**	**AutoCAD**	**yes**

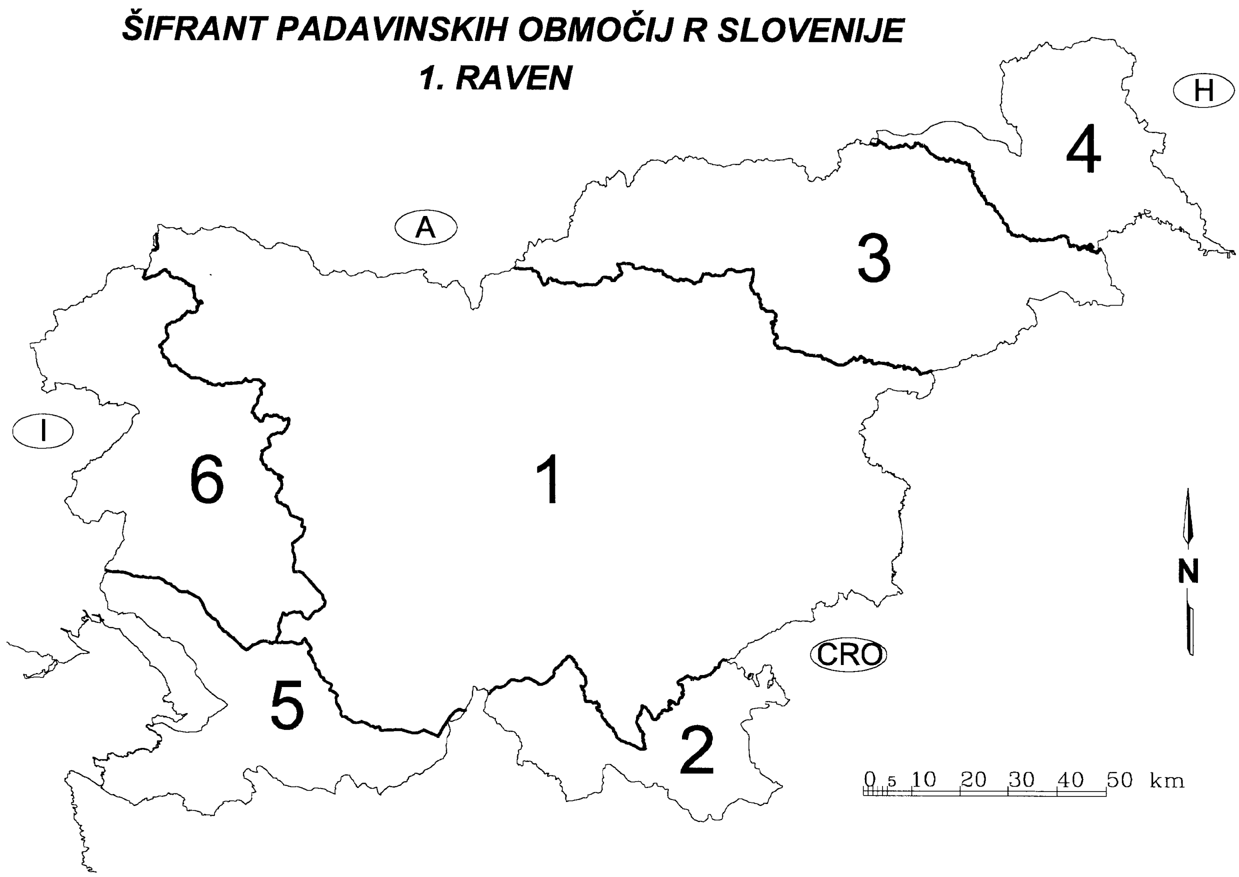
[1] planned for all Germany (1995); [2] Nordrhein-Westfalen

Na drugi ravni smo dobili 31 padavinskih območij, označenih z dvema številkama. Velikost padavinskih območij na drugi ravni je od 1,33 km^2 do 2250 km^2. Posamezna območja so nato hierarhično razdeljena na manjša po privzeti metodologiji. Številko 1 ima padavinsko območje izvira glavnega vodotoka. Padavinska območja stranskih pritokov so označena s parnimi števili 2, 4, 6 in 8. Padavinska območja, vezana neposredno na glavni vodotok pa z lihimi števili 3, 5, 7 in 9. Za določitev stranskih vodotokov je odločilna njihova velikost. Številka 0 pomeni, da se območje ne deli več.

Na tretji ravni smo izločili 156 padavinskih območij do velikosti 763 km^2.

On the second level, 31 watersheds characterised by two-figure numbers were obtained. The size of the watersheds on the second level is from 1,33 km^2 to 2250 km^2. The watersheds are then subdivided using adopted methodology. The source of the main stream is assigned number One. The even numbers 2,4,6 and 8 are assigned to the watersheds of tributary streams. Main stream watersheds are assigned the odd numbers 3,5,7, and 9. The determination of tributary watersheds depends on their size. Number 0 means that there is no further division.

On the third level, 156 watersheds were assigned to the size of 763 km^2.



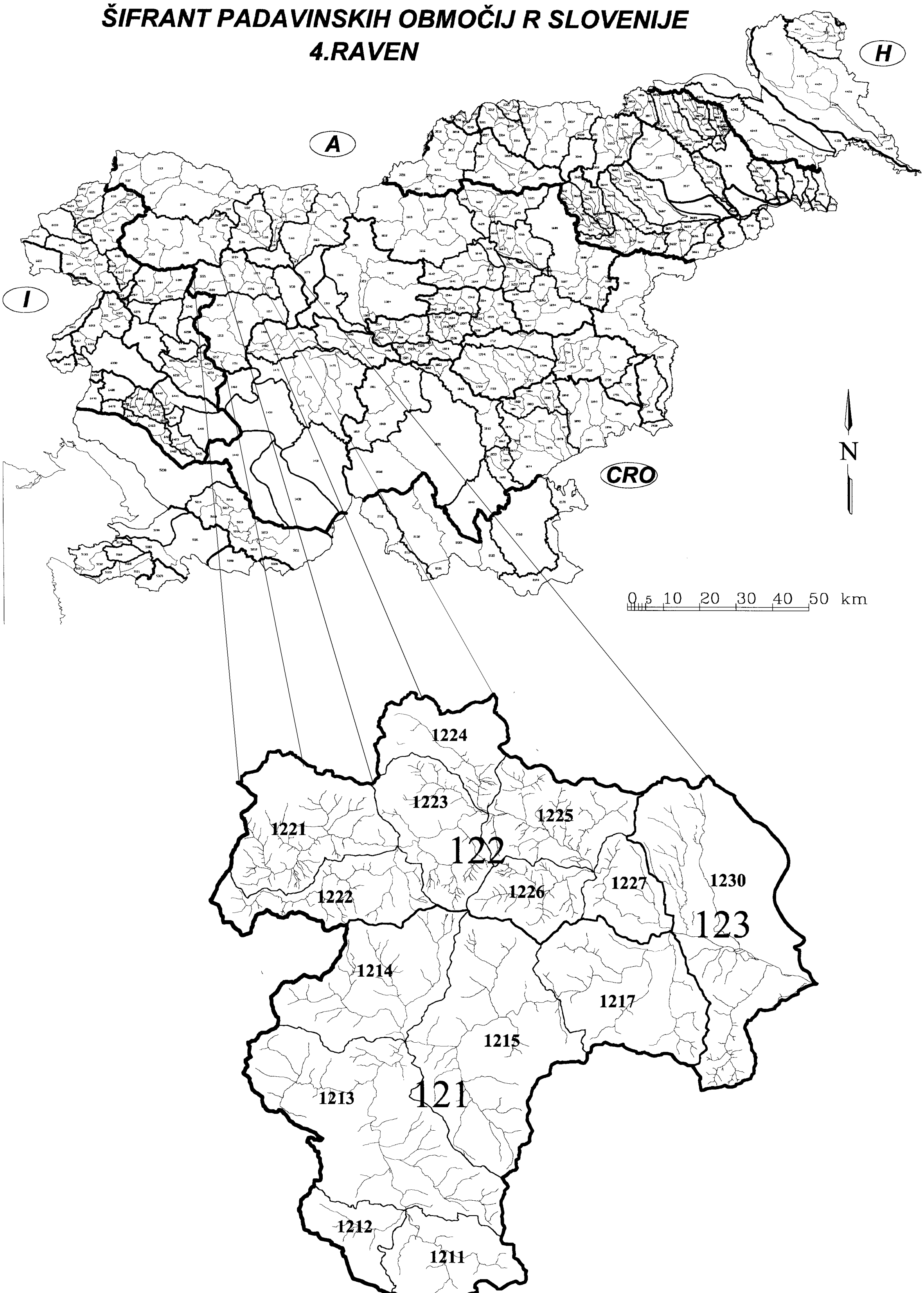
Slika 8. Šifrant padavinskih območij Republike Slovenije na prvi ravni.
Figure 8. The first level of the Slovenian watershed coding system.

Šifrant je izdelan do četrte ravni (štiri številke) (slika 9). S štirimestno šifro so bila za potrebe nacionalnega vodarskega informacijskega sistema v Sloveniji identificirana padavinska območja do 531 km^2 (Šraj, 2000). Na kraških območjih (Ljubljanica, Krka, Kolpa in Vipava) četrte ravni ni bilo mogoče izdelati. Narejenih je bilo nekaj meritev s sledili, vendar premalo. Sicer pa smo pri določanju kraških padavinskih območij upoštevali poglavitne dokazane podzemne povezave. Pri številčenju smo upoštevali tudi pomen obmejnih vodotokov in jim s podrobnejšo razdelitvijo dali večjo težo.

Šifrant Slovenije je bil izdelan leta 1996 kot Temeljni projekt hidrografije (Brilly & Garantini, 1996). Izdelan je bil v obliki preglednic in kart. Podatki pa so bili vnešeni v GIS (Brilly & Šraj, 1998).

The coding system is completed to the fourth level (four-figure numbers) (Figure 9). Watersheds of up to 531 km^2 with four-figure numbers were identified for the needs of the national water information system of Slovenia (Šraj, 2000). It was impossible to define the fourth level watershed boundaries in the Karst regions (The Ljubljanica, Krka, Kolpa, and the Vipava rivers). There were some tracking measurements, but not enough. Otherwise, all proved groundwater connections were considered. By coding we also considered the importance of transboundary streams and gave them greater significance with detailed subdivisions.

The coding system of Slovenia was developed in 1996 as a fundamental hydrographic project (Brilly & Garantini, 1996). It was made in the form of tables and maps. Data were entered in the GIS (Brilly & Šraj, 1998).



Slika 9. Šifrant padavinskih območij Republike Slovenije na četrti ravni.
Figure 9. Fourth level of the Slovenian watershed coding system.

5. ZAKLJUČKI

Pomen šifranta padavinskih območij R Slovenije je izjemen. Predstavlja temelj sodobnega informacijskega sistema za potrebe varstva okolja, urejanje podatkov o okolju, njihovo obdelavo in statistično analizo, za izdelavo vodnogospodarskih načrtov, programov, katastra vodnogospodarskih objektov in drugih prostorsko določenih podatkov.

Šifrant padavinskih območij omogoča tudi šifriranje strug posameznih vodotokov. Šifre, tako kot pri padavinskih območjih, označujejo pomen in delno klasifikacijo vodotoka. Tako s pomočjo preprostih pravil dosežemo, da imata padavinsko območje in njegov glavni odvodnik enako šifro.

Sistem šifriranja padavinskih območij v Sloveniji je strukturiran tako, da omogoča preprosto programiranje in neposreden vnos v hidrološke modele.

Šifrant padavinskih območij Republike Slovenije omogoča temeljno kategorizacijo vodotokov po hidrološkem pomenu in zasnovo klasifikacije po vodarskem pomenu.

5. CONCLUSIONS

The coding system of the Republic of Slovenia is significant. It represents the basis of contemporary information system for environment protection, environmental data management, data handling and statistical analysis, water management plans and programmes, cadastre of hydraulic structures and other space related data.

The watershed coding system also enables stream coding. The stream codes, the same as those of the watersheds, indicate the meaning and partly the classification of the stream. So with simple rules it is achieved that the watershed and its main stream have the same number.

The structure of the watershed coding system of Slovenia enables simple computer programming and direct hydrological modelling.

The coding system of the Republic of Slovenia enable the fundamental categorisation of streams by hydrological meaning and the scheme of classification by water management meaning.

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